

## CLAIMS

1. A device for inspecting the inside of an underground pipe line, which is provided with a radar for inspecting cavities present in at least part of the ground surrounding the underground pipe, the device comprising:

a pipe line internal self-propelled vehicle, which comprises an antenna for said radar and moves inside the pipe line of said underground pipe; and

an on-ground control unit for conducting control of said movement of the pipe line internal self-propelled vehicle and processing signals of said radar, wherein

said pipe line internal self-propelled vehicle comprises an antenna rotation mechanism for rotating said antenna along the inner peripheral surface of said underground pipe and capable of changing the position of said antenna so that said antenna follows said inner peripheral surface.

2. The device for inspecting the inside of an underground pipe line according to claim 1, wherein

said pipe line internal self-propelled vehicle comprises a height adjustment mechanism capable of changing the position of said antenna rotation mechanism in the up-down direction inside said pipe line of said underground pipe according to the inner diameter of said underground pipe so that the rotation center of said antenna coincides with the center of the inner diameter of said underground pipe.

3. The device for inspecting the inside of an underground pipe line according to claim 1 or 2, wherein

said pipe line internal self-propelled vehicle comprises antenna position detection means for detecting the position of said antenna, and

in said on-ground control unit, signals of said radar are analyzed and radar images of the ground surrounding said underground pipe in a plurality of directions perpendicular to the traveling direction of said pipe line internal self-propelled vehicle are created as two-dimensional radar images for each said direction and displayed in a real time mode.

4. A device for inspecting the inside of an underground pipe line, which is provided with a radar for inspecting cavities present in at least part of the ground surrounding the underground pipe, the device comprising:

a pipe line internal self-propelled vehicle, which comprises an antenna for said radar and moves inside the pipe line of said underground pipe; and

an on-ground control unit for conducting control of said movement of the pipe line internal self-propelled vehicle and processing signals of said radar, wherein

said pipe line internal self-propelled vehicle comprises a parallel link mechanism for supporting said antenna positioned above said pipe line internal self-propelled vehicle, so that said antenna can be lifted or

lowered according to the height of the ceiling inside the pipe line of said underground pipe.

5. The device for inspecting the inside of an underground pipe line according to claim 4, wherein

respective linkages of said parallel link mechanism have a variable length and can be extended or contracted, and the upper surface of said antenna can be tilted forward and backward so as to follow the shape of said ceiling.

6. The device for inspecting the inside of an underground pipe line according to any one of claims 1 to 5, wherein

said pipe line internal self-propelled vehicle comprises a fisheye lens camera for taking pictures of said inner peripheral surface of said underground pipe line forward in said traveling direction and the expanded image is created and displayed in a real time mode by said on-ground control unit from the images picked up with the fisheye lens camera.

7. The device for inspecting the inside of an underground pipe line according to any one of claims 1 to 6, wherein

said pipe line internal self-propelled vehicle comprises a gyro for measuring the inclination of said pipe line internal self-propelled vehicle in the traveling direction with respect to the horizontal direction and a

laser sensor for rotating along said inner peripheral surface of said underground pipe to measure the convergence of said underground pipe over the entire inner peripheral surface, and

the signals of said gyro and the signals of said laser sensor are analyzed in said on-ground control unit to create three-dimensional convergence images and display them in a real time mode.

8. The device for inspecting the inside of an underground pipe line according to claim 6 or 7, wherein

in said on-ground control unit, the correspondence is established between said radar image and said expanded image in the same observation point or, when said convergence image is present, the correspondence is established between said radar image, said expanded image, and said convergence image in the same observation point.

9. The device for inspecting the inside of an underground pipe line according to any one of claims 1 to 8, wherein said pipe line internal self-propelled vehicle comprises an infrared encoder for measuring the travel distance thereof.

10. The device for inspecting the inside of an underground pipe line according to claim 6, wherein said underground pipe is made from concrete, and said pipe line internal self-propelled vehicle comprises spraying means for spraying a concrete deterioration diagnostic reagent,

which changes the color of the surface to which it has adhered according to the presence or absence of concrete deterioration, on the inner peripheral surface of said concrete in said underground pipe line when said self-propelled vehicle moves inside the pipe line.

11. The device for inspecting the inside of an underground pipe line according to claim 10, wherein a reagent for judging the presence or absence of deterioration caused by sulfuric acid is used as said concrete deterioration diagnostic reagent.

12. The device for inspecting the inside of an underground pipe line according to claim 10 or 11, which comprises a sensor for detecting toxic gases such as hydrogen sulfide.

13. The device for inspecting the inside of an underground pipe line according to any one of claims 10 to 12, wherein

said pipe line internal self-propelled vehicle comprises a gyro for measuring the inclination of said pipe line internal self-propelled vehicle in the traveling direction with respect to the horizontal direction and a laser sensor for rotating along said inner peripheral surface of said underground pipe to measure the convergence of said underground pipe over the entire inner peripheral surface, and

the signals of said gyro and the signals of said laser sensor are analyzed in said on-ground control unit to create three-dimensional convergence images and display them in a real time mode.

14. The device for inspecting the inside of an underground pipe line according to any one of claims 10 to 13, wherein

in said on-ground control unit, the correspondence is established between said radar image and said expanded image in the same observation point or, when said convergence image is present, the correspondence is established between said radar image, said expanded image, and said convergence image in the same observation point.

15. The device for inspecting the inside of an underground pipe line according to any one of claims 10 to 14, wherein said pipe line internal self-propelled vehicle comprises an infrared encoder for measuring the travel distance thereof.

16. A method for inspecting the deterioration of concrete inside an underground pipe line by using the device for inspecting the inside of an underground pipe line according to any one of claims 10 to 15,

wherein said spraying means sprays a concrete deterioration diagnostic reagent, which changes the color of the surface to which it has adhered according to the presence or absence of concrete deterioration, on the inner

peripheral surface of said concrete in said underground pipe line when said self-propelled vehicle moves inside the pipe line,

after said spraying, said fisheye lens camera takes pictures of said inner peripheral surface of said underground pipe line, and

said on-ground control unit creates said expanded image from said picked-up images, judges as to whether the deterioration of the inner peripheral surface of said concrete is present based on the expanded image and displays them in a real time mode.

17. A device for inspecting the inside of an underground pipe line, which is provided with a radar for inspecting cavities present in at least part of the ground surrounding the underground pipe, the device comprising:

an inspection unit having a cylindrical body for insertion into the pipe line of the underground pipe, wherein said radar is provided inside the body so that the electromagnetic waves thereof are emitted unidirectionally from the outer peripheral surface of said body toward the inner peripheral surface of said underground pipe;

an on-ground control unit for processing signals of said radar; and

a cable covered with a flexible tube having flexibility, the base end of which is connected to said on-ground control unit and the other end of which is coupled to the rear end of said inspection unit coaxially with the inspection unit, wherein said inspection unit is moved

forward or backward inside the pipe line of the underground pipe by pushing or pulling said flexible tube on the ground, and if said flexible tube is rotated about its axis on said ground, this rotation is transferred to said inspection unit via the flexible tube and said inspection unit rotates inside said pipe line of said underground pipe about the axis thereof.

18. The device for inspecting the inside of an underground pipe line according to claim 17, wherein supporters providing for smooth contact between said inspection unit and said inner peripheral surface when said inspection unit moves forward or backward or rotates about the axis thereof are provided on said outer peripheral surface of said inspection unit.

19. The device for inspecting the inside of an underground pipe line according to claim 18, wherein the degree of protrusion of said supporters from said outer peripheral surface changes according to changes in the inner diameter of said underground pipe, so that the top portions of said supporters are brought into contact with the inner peripheral surface of said underground pipe.

20. The device for inspecting the inside of an underground pipe line according to any one of claims 17 to 19, wherein

the base end of said cable is connected to said on-ground control unit via a cable winding unit for winding up the cable, and

said cable winding unit is provided with a rotary mechanism which rotates said flexible tube covering said cable about its axis.

21. The device for inspecting the inside of an underground pipe line according to any one of claims 17 to 20, wherein said inspection unit is provided with a gyro for measuring the rotation axis direction and rotation angle of said inspection unit when the inspection unit rotates about its axis.

22. The device for inspecting the inside of an underground pipe line according to any one of claims 17 to 21, comprising an encoder for on-ground measurements of the draw-out length of said cable in the insertion direction when said inspection unit is inserted into said pipe line of said underground pipe.

23. The device for inspecting the inside of an underground pipe line according to any one of claims 17 to 22, wherein a fisheye lens camera for taking pictures of the inner peripheral surface of said pipe line of said underground pipe forward in the insertion direction is provided at the front end of said inspection unit and an expanded image is created and displayed in a real time mode

by said on-ground control unit from the images picked up with the fisheye lens camera.

24. A method for inspecting the inside of an underground pipe line by using the device for inspecting the inside of an underground pipe line according to any one of claims 17 to 23, wherein

the distance traveled by said inspection unit inside said pipe line of said underground pipe is found by the draw-out length of said cable in said insertion direction and the position in which said inspection unit is located inside said pipe line is recognized, and

said inspection unit is rotated inside said pipe line of said underground pipe by rotating said flexible tube covering said cable about its axis and cavities present in the ground surrounding the underground pipe are inspected over the entire periphery of said underground pipe.